

Next Generation Life Support (NGLS): Rapid Cycle Amine (RCA) Swing Bed Element

Game Changing Development Program | Space Technology Mission Directorate (STMD)



ANTICIPATED BENEFITS

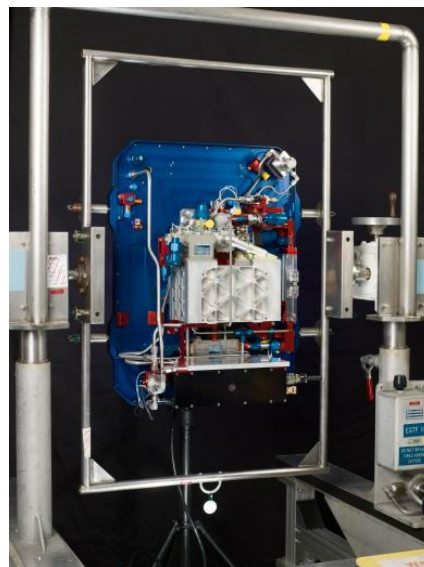
To NASA funded missions:

This project will mature the technology from proof-of-concept by building a full sized assembly, RCA 2.0, which will consist of an integrated rectangular canister and ganged ball valve. The ball valve concept was selected for this iteration based on the valve reliability from related projects. RCA 2.0 will be fabricated, tested, and evaluated in cooperation with the AES Advanced EVA Systems Development project in their packaged PLSS (PLSS 2.0) integrated test, which will involve vacuum chamber testing of a packaged PLSS using a metabolic simulator and nitrogen gas as the working fluid. In the third year of NGLS, a high fidelity oxygen compatible unit will be developed (RCA 3.0) for evaluation in human vacuum chamber tests with 100% oxygen as the working fluid. This will be infused within PLSS 2.5 for integrated testing.

DETAILED DESCRIPTION

The Rapid Cycle Amine (RCA) swingbed has been identified as a technology with high potential to meet the stringent requirements for the next generation spacesuit's CO₂ removal and humidity control system. The pursuit of this new technology has been driven by mission applications beyond ISS. Those missions will require space walks for use at destinations such as near-earth Objects (NEOs) and surface missions to the moon, Phobos, or Mars. These destinations necessitate that the technology be operable over a wide range of mission conditions and human metabolic loads, and over long durations of time with minimal power and consumable loss.

The focus of the Rapid Cycle Amine (RCA) Element is to develop an integrated CO₂ removal and humidity control system that can be regenerated in real time during an ExtraVehicular Activity (EVA) event. Not only does this capability eliminate

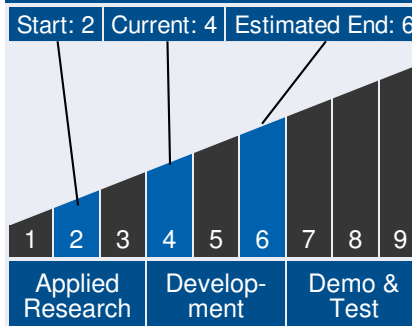


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Technology Maturity



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consumables associated with non-regenerable technologies, the RCA eliminates off-suit regeneration that requires ancillary equipment and power, and eliminates CO₂ scrubbing as an EVA duration limitation. The amine used in the swing bed also removes water vapor from the suit ventilation loop, thereby eliminating the need for a condensing heat exchanger, slurper, and rotary separator, as is used with the current Advanced Extravehicular Mobility Unit (EMU).

Over the last several years the RCA swing-bed technology has gone through a sequence of design, development, test, and evaluation to prove the technology viable for EVA applications. These previous efforts have investigated the scalability of the technology, sorbent canister geometries, flow control valve designs, and process control schemes aimed at optimizing the RCA for system integration into an advanced Primary Life Support System (PLSS). The sequence of development has taken the technology through three design cycles.

Attributes of three generations of hardware, RCA 1.0, 2.0 and 3.0, are given in the table below.

Significant accomplishments since the beginning of the project include:

- Completion of testing of first generation hardware (RCA 1.0). Data were used to inform the design of second generation hardware and develop algorithms for its control system.
- Design and fabrication of second generation hardware (RCA 2.0). The project's target of a mass reduction of 67% as compared to the state-of-the-art (SOA) was exceeded.
- Integration of the RCA 2.0 test article into the PLSS 2.0 test article and completion of performance testing as part of the integrated test. At the completion of this testing the RCA reached a TRL of 5.

Continued on following page.



4 Conference Papers

Management Team

Program Executive:

- Lanetra Tate

Program Manager:

- Mary Wusk

Project Manager:

- Daniel Barta

Technology Areas

Primary Technology Area:

Human Health, Life Support, and Habitation Systems (TA 6)

- └ Extravehicular Activity Systems (TA 6.2)
 - └ Portable Life Support System (TA 6.2.2)
 - └ Alternate CO₂ Sorbent (TA 6.2.2.8)

Secondary Technology Area:

Human Health, Life Support, and Habitation Systems (TA 6)

- └ Environmental Monitoring, Safety, and Emergency Response (TA 6.4)

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- Design and fabrication of the Suited Manikin Test Apparatus (SMTA) and Ventilation Test Stand.
- Design of third generation (RCA 3.0) hardware. Differences between RCA 1.0, 2.0 and 3.0 are given below.
- Fabrication and life testing of the RCA 3.0 valve assembly.
- Fabrication of the full RCA 3.0 test article is expected to be completed in February 2015. This unit will be rated for use with 100% oxygen. Once environments testing has been completed and following future human testing (to be conducted by the AES Advanced Space Suit Project) RCA 3.0 will be at a TRL of 6.

The SMTA and Ventilation Test Stand were developed to perform unit functional testing of RCA hardware with a simulated relevant environment. The SMTA makes use of a Space Suit Assembly Simulator (SSAS) to provide an accurate atmospheric volume. A manikin inside the SSAS simulates a crew member's displacement of atmospheric volume, and duplicates ventilation flow patterns in a similar way that a crewmember would in a donned suit. In addition, the manikin is configured to simulate human breathing patterns. Environmental conditions within the SMTA are controlled and include pressure, humidity, CO₂ partial pressure and temperature. The manikin wears a Liquid Cooling and Ventilation Garment. A range of human metabolic loads can be simulated. For cost and safety, the systems will operate with an internal atmosphere of nitrogen or air, as they have not been designed for use with 100% oxygen.

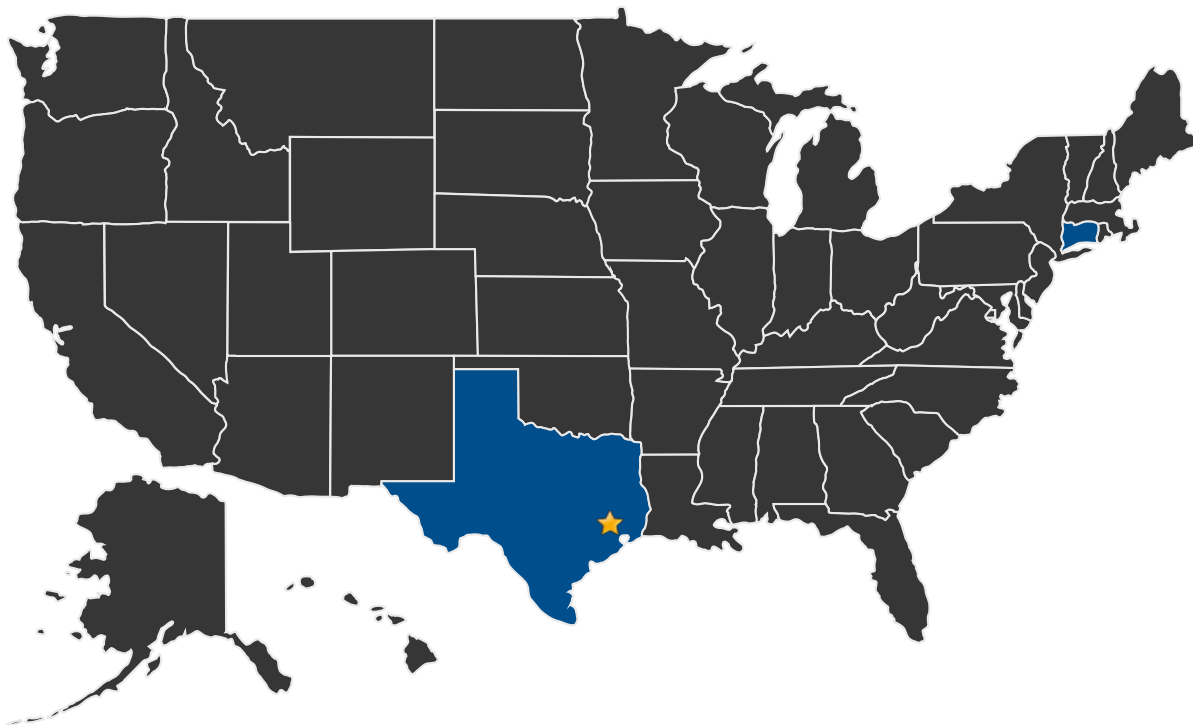
The RCA uses a multi-chambered ball valve assembly to switch ventilation loop flow between its two beds. While one bed is open to the suit to scrub CO₂ and moisture, the second bed is desorbing to space vacuum. Accelerated life testing was performed on a high fidelity valve assembly for RCA 3.0. The testing was performed for design validation, to mitigate risk of valve failure and to identify any potential unexpected wear internal to the assembly. Because the valve is expected to cycle 40 to 50 times per EVA, and the RCA is rated for 100 EVAs, the valve assembly is expected to experience approximately 5,000 valve cycles over its lifetime. The valve was cycled at an accelerated rate over a period of about 4 months, completing 105,089 cycles, about 21 times the rated design life. Leakage remained within specifications during this period. The valve assembly is currently being dismantled for observation of any wear on critical parts.

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U.S. WORK LOCATIONS AND KEY PARTNERS



■ U.S. States With Work ★ **Lead Center:**
Johnson Space Center

Other Organizations Performing Work:

- United Technologies Aerospace Systems

ELEMENT LIBRARY

Conference Papers

- Continued Development of the Rapid Cycle Amine (RCA) System for Advanced Extravehicular Activity Systems
 - (<http://techport.nasa.gov:80/file/5001>)
 - Rapid Cycle Amine (RCA 2.0) System Development d
- Continued on following page.*

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Conference Papers (*cont.*)

- (<http://techport.nasa.gov:80/file/5005>)
- RCA 3.0 Development
 - (<http://techport.nasa.gov:80/file/17411>)
- Suited Manikin Test Apparatus
 - (<http://techport.nasa.gov:80/file/17412>)

DETAILS FOR TECHNOLOGY 1

Technology Title

Rapid Cycle Amine (RCA) Swing Bed

Technology Description

This technology is categorized as a hardware assembly for other applications

Rapid cycling amine (RCA) technology provides carbon dioxide removal, humidity control, and re-generates in real time during space walks using cyclic exposure to space vacuum.

Capabilities Provided

This unique RCA regenerative design approach reduces space suit complexity by eliminating several onboard components associated with humidity control and fluid handling. The RCA was fabricated as the first full-sized assembly and integrated into a prototype of an advanced space suit Portable Life Support System (PLSS).

Potential Applications

Further maturation of the design will include certification for use with 100% oxygen and compatibility with spacelike environments.